In normal A.C. mains receivers with parallel connected valve heaters, a substitute valve must have the same heater voltage rating, differences in current being of small importance. An exception occurs in the case of certain obsolete rectifying valves having a very low heater current. Substitution by a modern type may cause excessive voltage drop in the transformer winding. Provided the H.T. current drawn by the receiver is well within the rating of the new valve, however, a drop of 10 per cent in heater voltage will not seriously shorten its life. For 6 volt car radios and 12 volt receivers employing 12 volt valves the same considerations apply as for A.C. receivers.

Many 12 volt receivers employ series-connected pairs of 6 volt valves, connected directly across the battery. In these cases, both heater voltage and current are important. Current differences may be balanced by fitting the correct value of resistor across the heater drawing the lower current.

SOCKET CHANGES

When socket changes and rewiring are involved the positioning of the leads is of importance. Heater leads must be kept clear of grid connections, whilst the control grid and anode connections of R.F. valves must be placed well apart or instability will result. Single ended valves are particularly prone to trouble from this cause

Replacement of a valve having a top anode connection by one having a top cap grid requires special care. The new top cap connection is best brought from the top of the coil can, the old anode connection being withdrawn and brought out from the bottom. This will avoid the necessity of employing a long length of screened lead which besides increasing the capacity of the tuned circuit, usually has a very poor power factor, resulting in loss of gain.

OPERATING CONDITIONS

The substitute valve may require a lower or higher screen voltage for optimum results, a change of bias or optimum load may also be advisable. Always ensure that the voltages and currents are within the maximum ratings given in the valve data sheet. Note that a valve may give satisfactory service in circumstances widely varying from the published operating conditions provided the maximum ratings (including anode and screen dissipation) are not exceeded.

FREQUENCY CHANGERS

The older types of octodes and heptodes are interchangeable but it should be noted that the newer specialized types which have no oscillator anode cannot be used for replacement without considerable circuit modification. Valves of this type include the 1R5, 6BE6 and 6SA7. Type 6SA7 may be replaced by type 6K8GT together with slight wiring changes, in sets without a short-wave band.

Triode-heptodes and triode-hexodes are interchangeable when used for frequency conversion. The triode-heptode employs a suppressor grid to increase the conversion impedance and so reduce the I.F. transformer damping. This feature is achieved in types 6K8GT and 12K8GT by the addition of confining plates.

The triode-pentode used with cathode injection is conveniently replaced by a pentagrid or triode-hexode of more modern design. A change in value of screen grid and oscillator anode resistors will usually be necessary, to ensure that the valve ratings are not exceeded.

Early sets employing H.F. tetrodes as self-oscillating frequency changers may be Brimarized by the use of a modern H.F. pentode of the "sharp cut-off" type. Vari-mu valves are not usually satisfactory owing to their lower conversion factor. Note that the metallizing on 5-pin valves is connected to cathode and in this circuit will be at R.F. potential. If instability results, a clear type should be used or a 7-pin type substituted and its metallizing earthed

A Heptode used with a separate oscillator valve may usually be replaced by a modern type of triode-hexode, the oscillator anode connection being taken to cathode.

Always re-align the receiver after substitution of the frequency changer. Whistles present after re-alignment may be due to excessive oscillation and this may be reduced by inserting a resistor of 1,000 ohms or so in series with the oscillator grid coil of the appropriate wave band.

Strength of oscillation may be measured by inserting a 0.5 mA D.C. meter in the earthy end of the oscillator grid leak. The approximate peak heterodyne voltage may be obtained by multiplying the reading in milliamps by 1.2 and by the value of grid leak in thousands of ohms. The optimum value of grid current or heterodyne voltage is usually given in the valve ratings. In most receivers the figure will be achieved only at certain parts of the band, tolerances of ±50 per cent usually being satisfactory. Too low a value will cause greatly reduced gain.

Screen Grid Voltages.

The screen grid voltage for frequency changers and beam tetrodes should be obtained from a potentiometer, the resistor values employed being as low as practicably possible so that the variation in screen current between different valves does not affect appreciably the screen voltage. This is particularly important where more than one valve is supplied from the same potentiometer. R.F. pentodes with unaligned grids may employ a series screen resistor but the resultant lengthening of the grid base should be borne in mind if A.V.C. is used.

Suppressor Grid Voltage.

The suppressor grid should normally be maintained at cathode potential but it is permissible for certain applications to connect it to the negative end of the cathode resistor. In no circumstances must the suppressor grid be biased so far negative as to cause the safe screen dissipation to be exceeded nor should it be biased positively unless the data indicates that the valve has been designed for this use. When pentodes are connected as triodes the suppressor grid should be connected to the cathode.

Magnetic Fields.

The modern trend in miniature equipment may result in valves being mounted in close proximity to the magnets of loud-speakers. The presence of a strong magnetic field will cause changes in the characteristics of the valve. The 1.4 volt battery types are particularly liable to be affected and due regard should be paid to this in the layout of equipment.

Rectifiers.

The value of limiting resistor specified includes the effective supply impedance of the mains transformer, or in certain A.C./D.C. receivers the mains dropping resistor, so that additional resistance may be required to build up to the value given. This resistance will be required to carry the R.M.S. rectifier current which will be greater than the D.C. output current by the factor indicated on p. 271 of the Brimar Manual No. 7. If the value of the reservoir condenser to be used is greater than the maximum specified, the limiting resistance must be increased to ensure that the peak current rating is not exceeded.

If rectifiers are to be operated in parallel a resistance of approximately 100 Ω should be connected in each anode lead to ensure balance of load distribution.

Series Operation of Filamentary Types.

In this mode of operation the total filament current is the sum of the current due to the filament supply and the anode and screen currents returning to H.T. negative via the valve filaments. It is, therefore, necessary to connect shunt resistors across each filament section to by-pass this electrode current in order to maintain the correct filament voltage.

TELETUBE RATINGS

Heater Voltages and Currents

The heater voltage of tubes intended for use with their heaters run in parallel with other heaters should be maintained within ±7 per cent of the rated value. Due allowance should be made for any voltage drop in the supply leads to the tube socket and heater voltages should always be checked at the socket with the tube inserted.

The heater current of tubes intended for use with their heaters run in series with other heaters should be maintained within ±5 per cent of the rated value.

Heater-Cathode Insulation

The heater to cathode potential should not be allowed to exceed the rated value for the tube, but when cathode modulation of the tube is used and its heater is not supplied from an isolated source, this rating may be exceeded for a short period, as is indicated in the tube data, while the receiver is warming up. In the case in which an isolated heater transformer winding is used, a resistance of the order of 100 kΩ should be connected between heater and cathode.

Grid

Normally the impedance between grid and cathode should not exceed 1 megohm.

Final Anode Voltage

Aluminised tubes have a minimum anode voltage below which low brightness and patchy pictures may be experienced. Maximum voltages should not be exceeded or the tube life will be impaired. Minimum and maximum voltages are stated for each type. Operation below the recommended anode voltage will result in a larger spot size and reduced peak brightness. Attempts to achieve the brightness obtainable at higher voltages by increasing the beam current may lead to defocusing of the highlights and short life.

X-Ray Warning

No harmful X-ray radiation is produced by any tube listed in this manual when operated at its maximum recommended final anode voltage provided this is not greater than 16 kV. At voltages above 16 kV shields may be needed to protect against possible injury from prolonged exposure at close range.

Focus

The optimum field and position of the focus coil or magnet is indicated in the tube data. Some means of adjustment of the position of the focus assembly relative to the axis of the tube neck should be provided to cover variations between tubes, between focus components or in the E.H.T. voltage used. The spot size is reduced as the focusing field approaches the screen, so that the siting of the field close to the gun is not recommended.

With tubes using electrostatic focus, care should be taken that the shift magnets used are not mounted so far back that they interfere with the passage of the electron beam through the gun and cause darkening or shading of the raster. With normal scanning coils the position of the shift magnets is immediately behind the scanning coils.

Ion Trap

Where an ion trap is used the ion trap magnet should be adjusted to give the brightest picture. Failure to do so may shorten the life of the tube.

BRIMARIZE SECTION

This section is written especially for the Service Engineer, to help him to select a satisfactory replacement valve for one that is obsolete or unobtainable.

A brief guide to the correct Brimarizing procedure is followed by a general consideration of the problem, particular reference being made to certain cases where conflicting requirements tend to cause confusion. The section closes with a list of tried and tested substitutions involving minor circuit changes.

Brimarize Procedure

1. Check valve function.

Determine whether the valve is being used normally, or for some special function. R.F. Pentodes are often used as frequency changers or as L.F. Amplifiers, whilst certain triode-pentodes and heptodes can be employed as I.F. and L.F. amplifiers simultaneously. In the latter case, Brimarizing may require two valves.

2. Check the heater rating.

In A.C. receivers the heater voltage is the important parameter whilst A.C./D.C. sets require the correct heater current rating. In car radios, both voltage and current may be important.

3. Check the base.

Valves with identical characteristics are often available in two base ranges. It may be more convenient to change the valve socket rather than make extensive circuit alterations.

4. Check the operating voltages and currents.

These must not exceed the maximum specified ratings for the valve nor should the receiver power supply be overloaded.

5. Check valve performance.

The sensitivity of a set fitted with A.V.C. or operated well within the Service Area may be reduced by 6db or so without noticeable change in performance. This is approximately equivalent to a 2 : 1 change in conversion or mutual conductance of a valve. Reduced power output may be nullified by fitting a loud speaker of high flux density.

NOTES ON BRIMARIZING

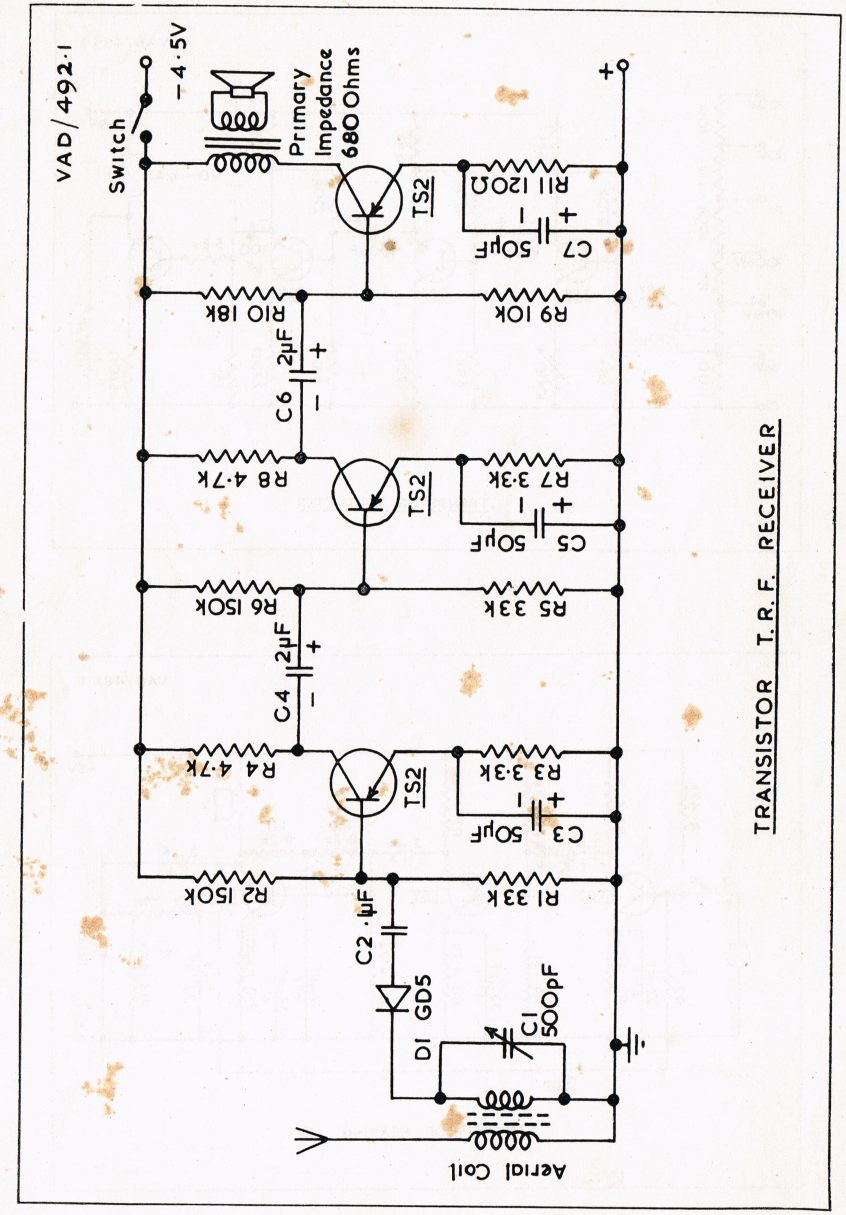
VALVE HEATERS

In A.C./D.C. and some A.C. receivers where several valves are connected in series, heater current is the important characteristic, slight differences in heater voltage being absorbed in the other valves and in the mains resistor. Where the voltage difference exceeds 5 per cent of the mains voltage, however, it is advisable to alter the value of this resistor. When a line cord is used which carries the H.T. current to the receiver, the total value of current flowing including H.T. must be employed in the calculation for resistance.

Receivers without barretters-or voltage tappings often give trouble in areas where the mains supply is on the low side (200 volts) or on the high side (250 volts). It is good practice to fit a tap on such receivers so as to provide the correct heater current at the nominal mains voltage of the locality.

Too low a current will cause premature loss of emission in rectifiers and output valves where these are used at maximum cathode ratings. Frequency changers tend to stop oscillating and this may cause the set to cease functioning during certain times of the day. Valves used for resistance coupled amplifiers or where very low ratings are employed may often be operated successfully at reduced heater currents.

Too high a heater current will cause premature heater failure, or heater-cathode leakage which may cause hum in the receiver. A secondary effect caused by excessive cathode temperature is grid emission. When this occurs on R.F. pentodes, gradual loss of gain results whilst in output valves an increase of distortion is noticeable a few minutes after "switch-on." Grid emission may be checked by inserting a 50 micro-amp. meter in series with the earthy end of the grid leak of the valve. A few micro-amps. will often be sufficient to cause trouble.



BRIMAR

FORMULAE IN RADIO ENGINEERING

1. OHMS LAW

If V equals the voltage existing across a resistance of R ohms when a current of I amperes is flowing, then :—

$$V = I \times R,\ I = \frac{V}{R},\ \text{or}\ R = \frac{V}{I}$$

2. POWER

Power is normally expressed in watts and given by the formula :—

$$W = V \times I = V^2/R = I^2 \times R$$

(V expressed in volts, I in amperes, R in ohms.)
NOTE—1 Horse Power = 746 watts.

3. RESISTORS IN SERIES AND PARALLEL

Series Connection.

The total resistance of a number of resistors connected in series is the sum of their separate resistances.

Parallel Connection.

The total resistance of a number of resistors connected in parallel is given by the equation :—

$$R = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$

where R1, R2 and R3 are the separate resistors. For two resistors only the formula becomes :—

$$R = \frac{R1 \times R2}{R1 + R2}$$

4. CAPACITORS IN SERIES AND PARALLEL

Parallel Connection.

The capacitance of two or more capacitors connected in parallel is equal to the sum of their capacitances.

Series Connection.

The total capacitance of a number of capacitors connected in series is given by the equation :—

$$C = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}}$$

where C1, C2 and C3 are the separate capacitors. For two condensers only the formula becomes :—

$$C = \frac{C1 \times C2}{C1 + C2}$$

5. REACTANCES OF CAPACITORS AND COILS

Capacitor Reactance $X_C = \frac{1}{2\pi fC}$ ohms

Coil Reactance $X_L = 2\pi fL$ ohms

$2\pi = 6.28$, f expressed in cycles per sec., C in farads, L in henries.

6. RESONANCE

At resonance $X_L = X_C$ and $f = \frac{1}{2\pi\sqrt{LC}}$

Alternatively $f = \frac{160}{\sqrt{LC}}$

(f in megacycles/sec., L in microhenries, C in micro-microfarads.)

7. Q FACTOR OF SINGLE TUNED CIRCUIT

$$Q = \frac{fo}{f_1 - f_2}$$

Where fo is the frequency giving maximum response, f_1 and f_2 the frequencies either side of fo where the response falls to 0.71 of maximum. All frequency measurements mu st be expressed in the same units.

Q factors of between 50 and 100 are normal for modern coils.

8. INDUCTANCE OF SINGLE LAYER COILS

$$L \text{ (in microhenries)} = \frac{a^2 N^2}{9a + 10l} \text{ approx.}$$

If desired inductance is known, the number of turns required may be determined by the formula :—

$$N = \frac{5L}{na^2}\left[1 + \sqrt{(1 + \frac{0.36n^2 a^3}{L})}\right]$$

N = number of turns.
a = radius of coil in inches.
n = number of turns per inch.
L = inductance in microhenries (μH).
l = length of coil in inches.

9. VALVE CHARACTERISTICS

Amp. factor (μ) = Impedance (r_a) X Mutual Conductance (g_m)

r_a measured in thousands of ohms, g_m measured in mA/volt.

Alternatively :—

$$g_m = \frac{\mu}{r_a}, \; r_a = \frac{\mu}{g_m}$$

10. STAGE GAIN

$$\text{Amplification (A)} = \frac{\mu \times R_a}{R_a + r_a}$$

where R_a is the anode load, measured in the same units as r_a. If R_a is small compared with r_a, e.g., television R.F. stages :—

$A = g_m \times R_a$ approximately.

11. NEGATIVE FEEDBACK

VOLTAGE FEEDBACK.

$$\text{Gain with feedback} = \frac{A}{1 + Ab}$$

where A is the original gain of the amplifier section over which feedback is applied (including the output transformer if necessary) and b is the fraction of the output voltage fed back.

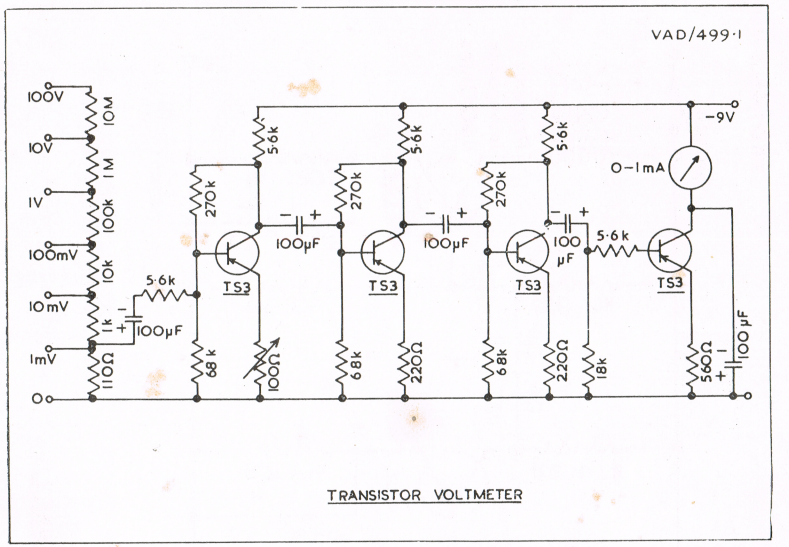
$$\text{Distortion with feedback} = \frac{d}{1 + Ab} \text{ approx.}$$

where d is the original distortion of the amplifier.

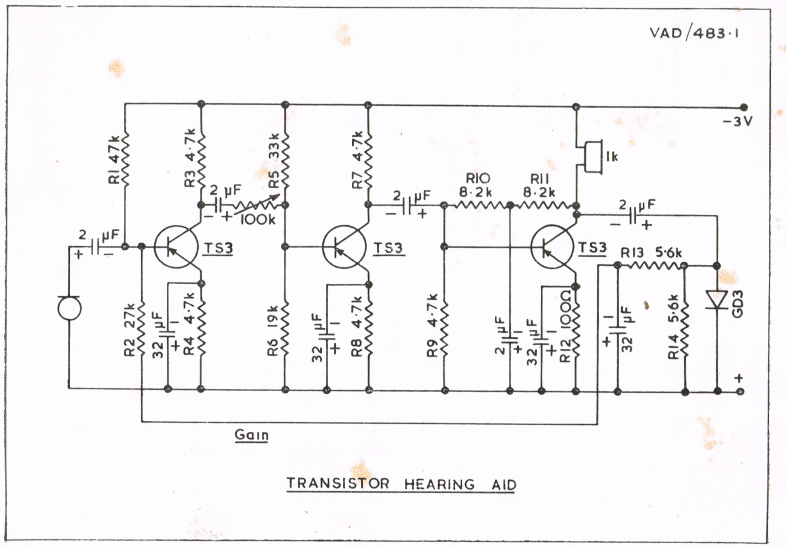
$$\text{Effective output Impedance} = \frac{r_a}{1 + \mu b}$$

where μ is the amplication factor of the output valve and r_a its anode impedance.

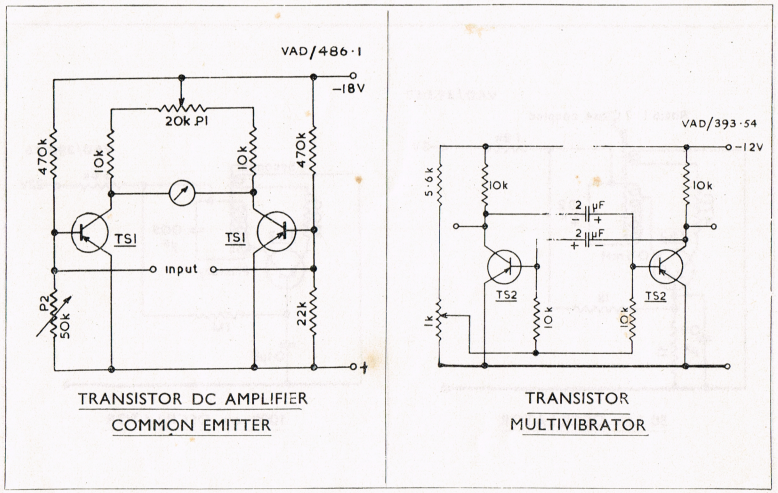
BRIMAR



TRANSISTOR VOLTMETER

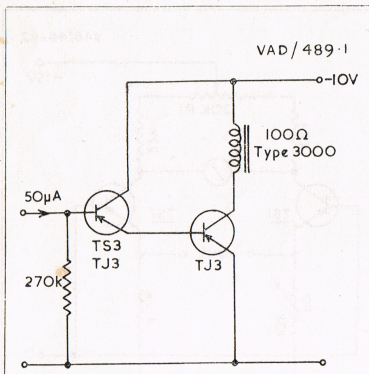


TRANSISTOR HEARING AID

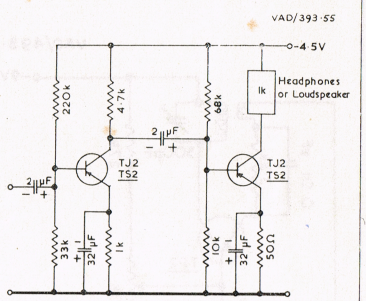


TRANSISTOR DC AMPLIFIER
COMMON EMITTER

TRANSISTOR
MULTIVIBRATOR



TRANSISTOR OPERATED RELAY



AUDIO AMPLIFIER

BRIMAR

CURRENT FEEDBACK.

This form of feedback may be secured by un-bypassing the cathode bias resistor. Current feedback results in an increase of effective output impedance and is not recommended for output stages.

12. DECIBELS

The bel may be defined as the common logarithm of the ratio of two powers. Normally the decibel (one-tenth of a bel) is employed as a more convenient unit.

$$\text{Decibels (db)} = 10 \times \log \frac{W_1}{W_2}$$

where W_1 and W_2 are the two power levels.

If equal impedances are employed :—

$$\text{Decibels} = 20 \times \log \frac{V_1}{V_2}$$

$$= 20 \times \log \frac{I_1}{I_2}$$

where V_1, V_2 are the two voltage levels and I_1, I_2 the two current levels.

db	Power Ratio	Voltage Ratio	db	Power Ratio	Voltage Ratio
1	1.26	1.12	15	31.6	5.62
2	1.58	1.26	20	100	10
3	2.0	1.41	30	1000	31.6
4	2.51	1.58	40	10^4	10^2
5	3.16	1.78	50	10^5	316
6	3.98	2.0	60	10^6	10^3
7	5.01	2.24	70	10^7	3160
8	6.31	2.51	80	10^8	10^4
9	7.94	2.82	90	10^9	31600
10	10	3.16	100	10^{10}	10^5

Figures not given in the table may easily be calculated. If two db figures are added, their corresponding power or voltage ratios must be multiplied together.

e.g., 45 db = 40 db + 5 db = 100 × 1.78 = 178 Voltage Ratio.

13. FORMULAE FOR EQUIVALENT R.F. NOISE RESISTANCE OF VALVES

Saturated Diode — $\text{Req.} = \frac{0.05}{I_a}$ ohms.

Space Charge Limited Diode — $\text{Req.} = \frac{0.0333}{I_a}$ ohms.

Triode — $\text{Req.} = \frac{2.5}{g_m}$ ohms.

Pentode — $\text{Req.} = \frac{I_a}{I_a + I_{g2}} \left(\frac{2.5}{g_m} + \frac{20 I_{g2}}{g_m^2} \right)$ ohms.

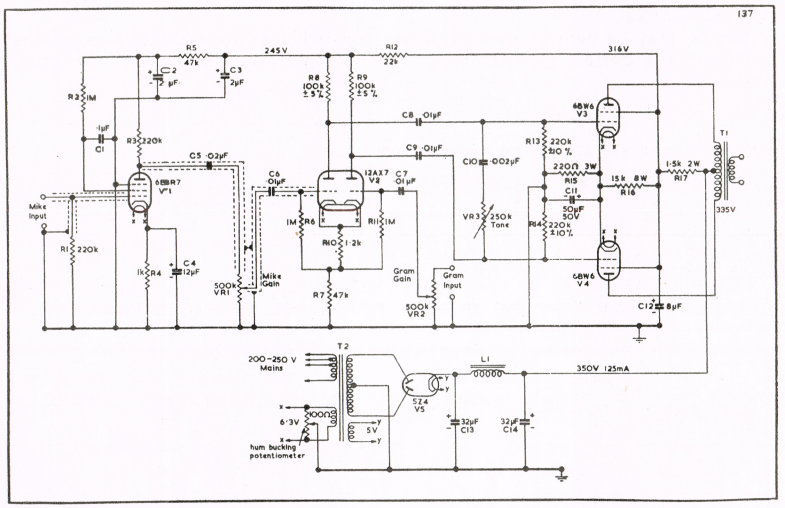
Triode Mixer — $\text{Req.} = \frac{4.0}{g_c}$ ohms.

Pentode Mixer and Multigrid Mixer — $\text{Req.} = \frac{I_a}{I_a + I_{g2}} \left(\frac{4.0 + 20 I_{g2}}{g_c \; g_c^2} \right)$ ohms.

I_a and I_{g2} are measured in amps., g_m and g_c are in amps. per volt.

CIRCUIT SECTION

6B W6 PUSH-PULL AMPLIFIER



Output transformer impedance 10,000 Ω anode to anode.

HARMONIC DISTORTION 1,000 c/s.

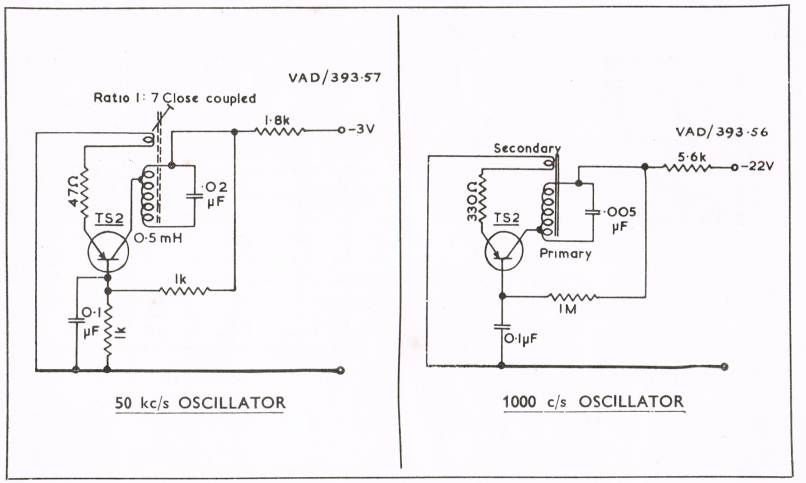
Output Watts	Mike		Gram	
	2nd	3rd	2nd	3rd
5	3.2	2.3	1	2.4
10	4.8	3.9	1.7	4.3
13	3.9	5.9	1.5	5.8

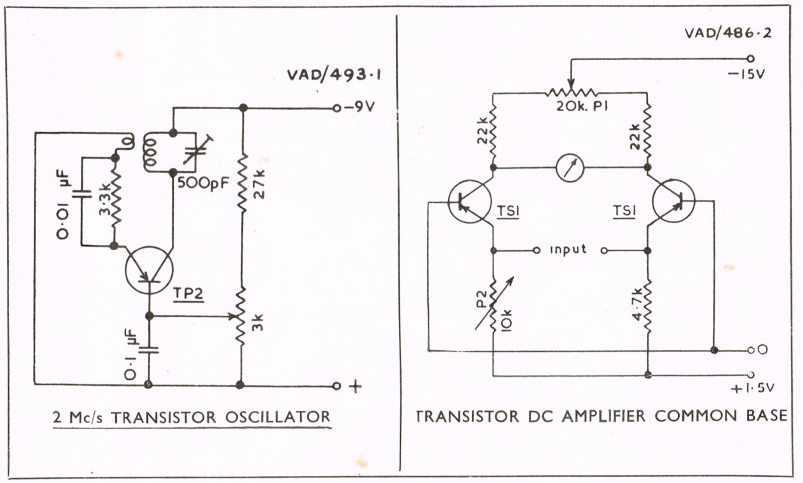
FREQUENCY RESPONSE 8 WATTS AT 1,000 c/s.

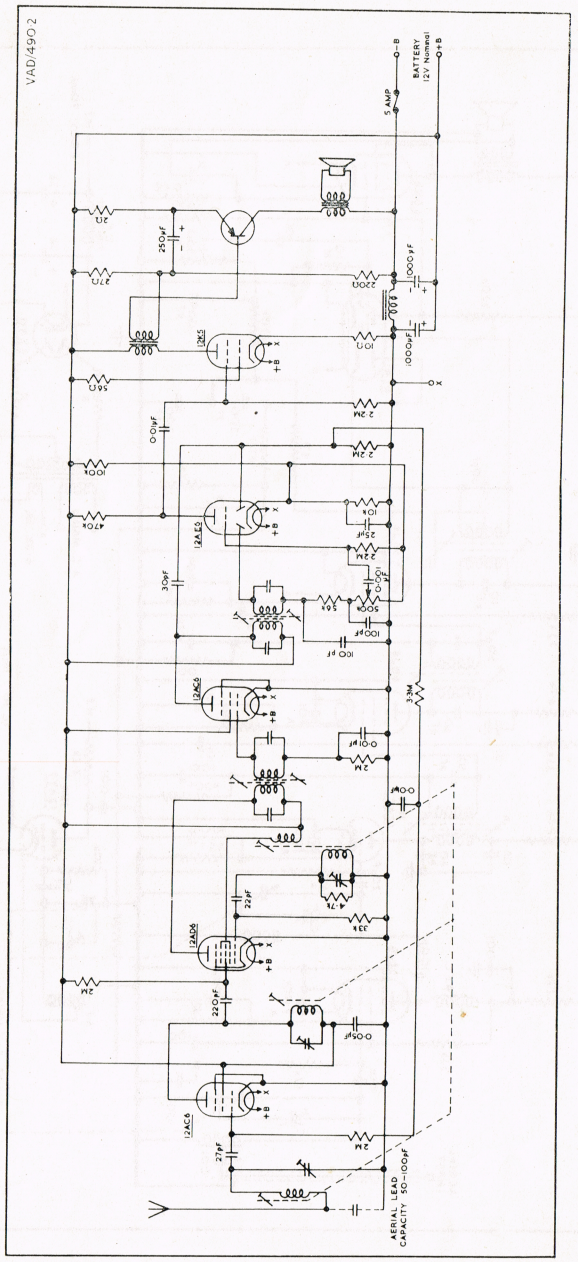
Frequency c/s	Gram db no top cut	Mike db no top cut	Mike db max. top cut
50	—2.0	—2.4	—2.4
200	0.2	0	+0.45
1,000	0.3	0	+0.25
3,000	0.3	0	—4
8,000	—0.4	—0.6	—10.2
15,000	—0.8	—1.7	—14.0

BRIMAR

TRANSISTOR CIRCUITS

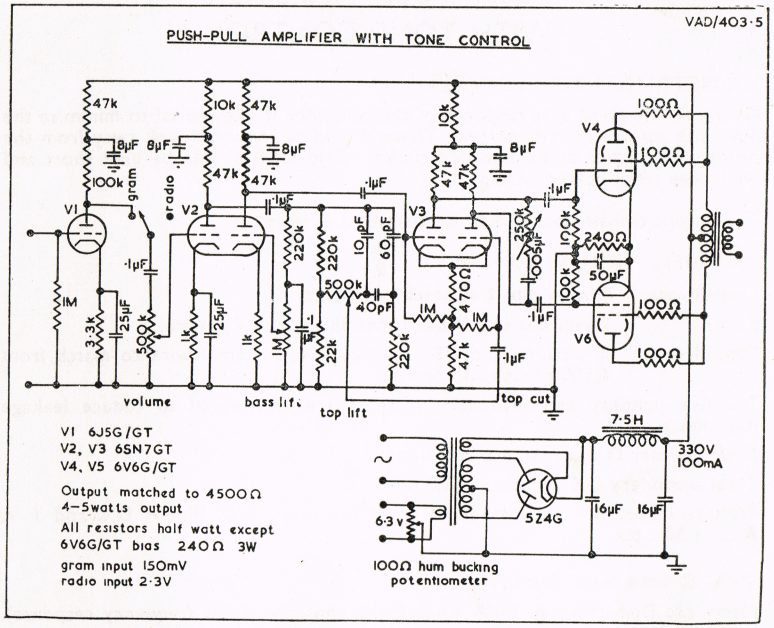


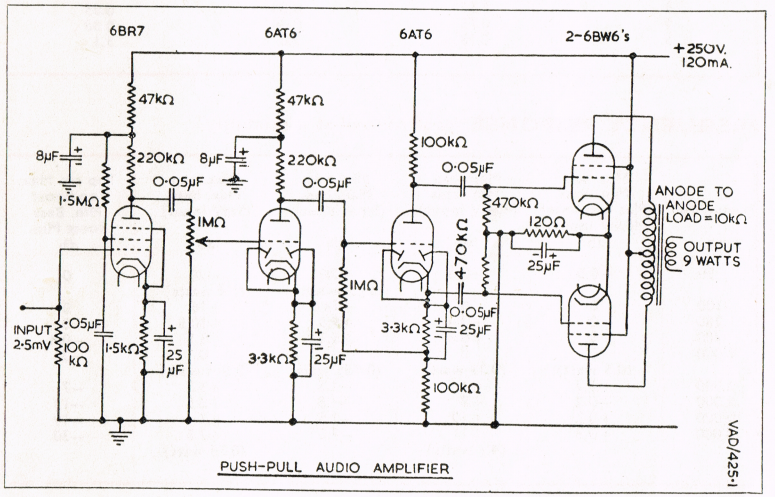




HYBRID CAR RADIO

BRIMAR





PUSH PULL AMPLIFIER WITH TONE CONTROL

CONSTRUCTIONAL NOTES

Owing to the good bass response of this amplifier it is essential to minimise the hum pick up in the early stages. These should be mounted well away from the mains transformer and smoothing choke. Grid leads should be kept short and well away from heater wiring.

The output transformer should be wound as follows :—

OUTPUT TRANSFORMER T2

Laminations — Sankey 60A ¾ in. stack butt joint.

Primary — 2 sections each 1,800 turns 36 s.w.g. S.S.E. wire.

Secondary — 3 sections each 70 turns 24 s.w.g. enamel wire to match from 4,500 ohms to 15 ohms.

The five primary and secondary sections are interleaved to reduce leakage inductance.

Total primary D.C. resistance 280 ohms.

Total secondary D.C. resistance 2.2 ohms.

Primary impedance approx. 5,000 ohms measured with 10 mA D.C and 1 V. A.C. at 50 c.p.s.

PERFORMANCE DATA

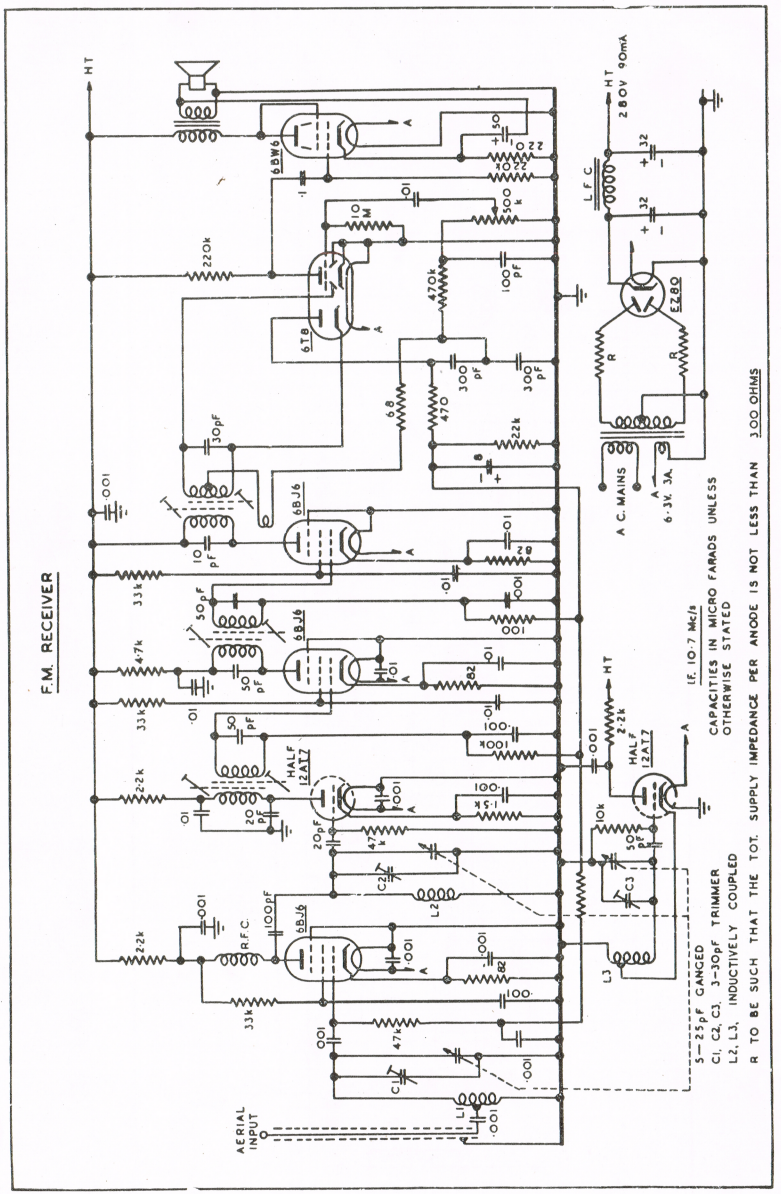
Harmonic Distortion at 1,000 c.p.s. (tone controls at flat frequency response).

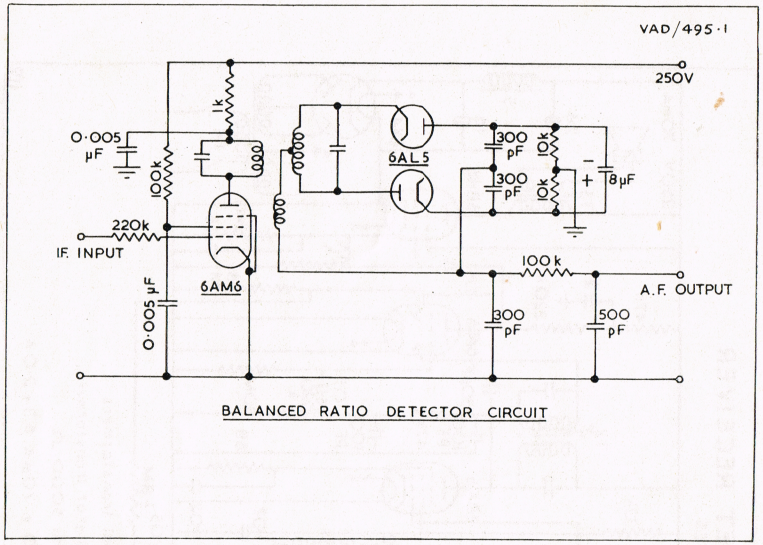
Output watts	% 2nd harmonic	% 3rd harmonic	Total harmonic
2	0.68	0.34	0.76
3	0.56	0.64	0.85
4	0.75	0.46	0.88
5	0.18	5.0	5.1

FREQUENCY RESPONSE (gain control at maximum)

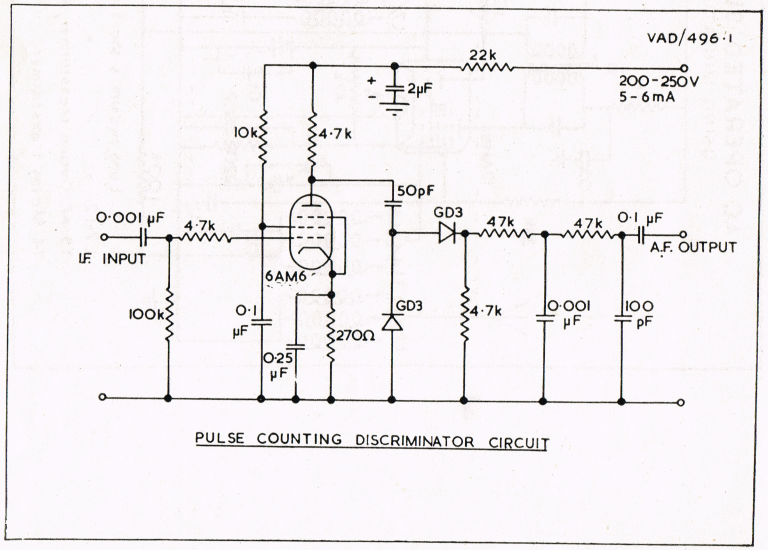
Frequency c.p.s.	Min. top Min. bass (Flat response) (40mV input) db	Max. top Min. bass (40mV input) db	Min. top Max. bass (5mV input) db	Max. top Max. bass (5mV input) db	Top cut Max. Top Boost Min. Bass Boost Min. db
50	—0.5	—0.4	+20 (3.5 watts)	+20 (1.4 watts)	0
100	0	0	+14.5	+16	0
200	0	+0.4	+9.5	+10.5	0
400	0	+0.4	+5.2	+5.5	—0.4
1,000	0 (0.5 watt)	0 (0.33 watt)	0 (0.035 watt)	0 (0.014 watt)	—2
2,500	—0.2	+1.4	—2.5	—3.5	—7
5,000	—0.2	+7	—3.5	+2.5	—13
10,000	+0.2	+10	—3.5	+7	—19
20,000	+0.3	+11 (4.1 watts)	—3.5	+7.5 (0.78 watt)	—30

BRIMAR

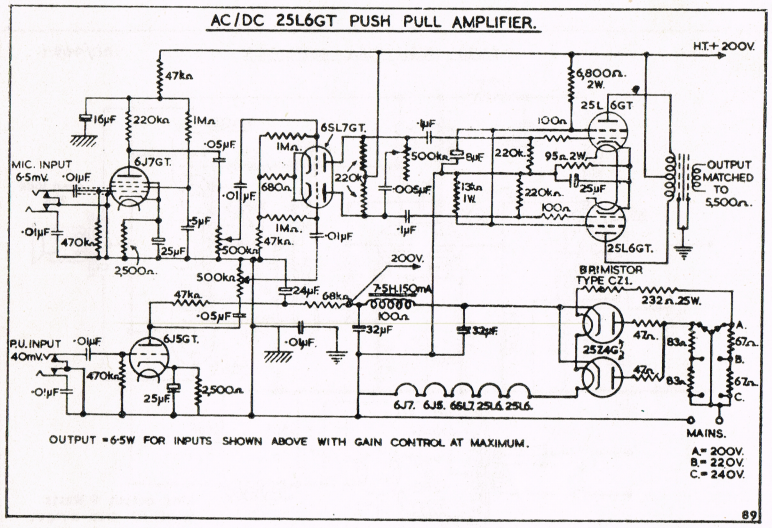


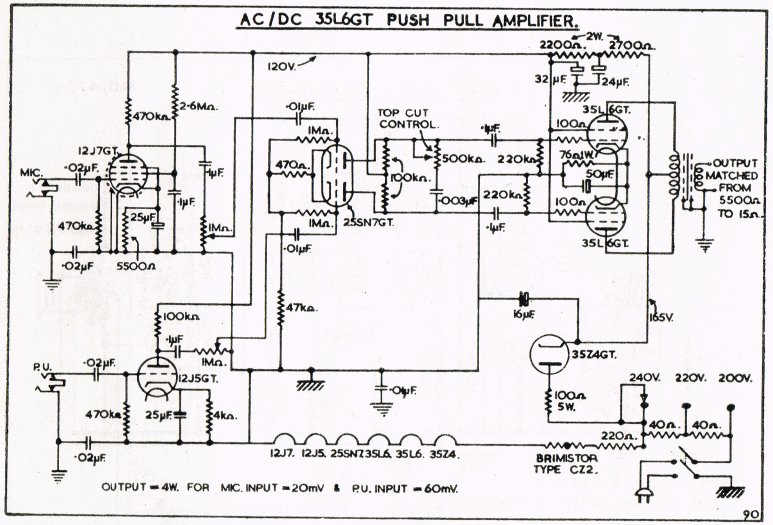


BALANCED RATIO DETECTOR CIRCUIT



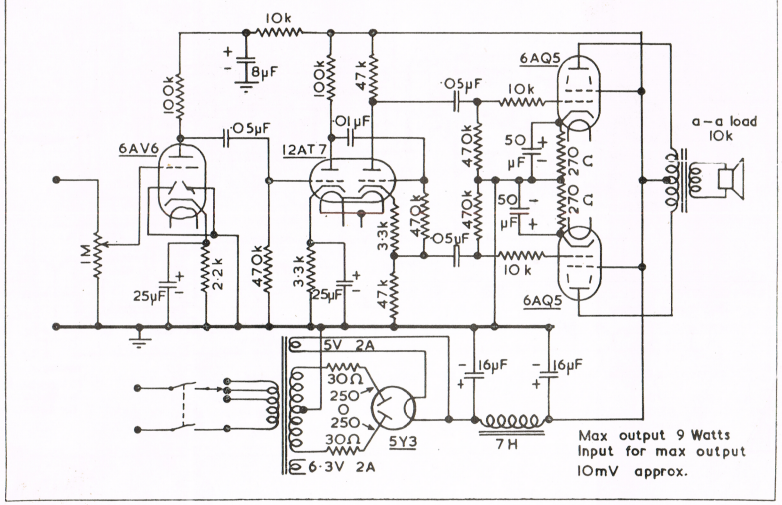
PULSE COUNTING DISCRIMINATOR CIRCUIT





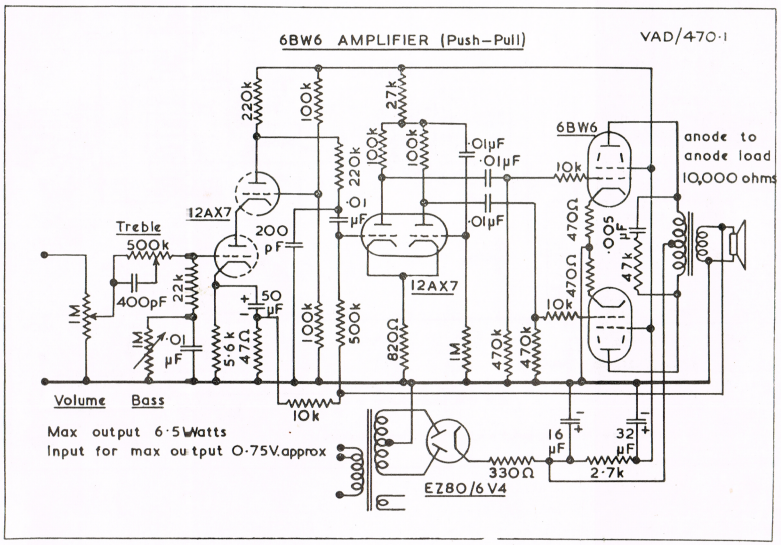
6AQ5 PUSH-PULL AMPLIFIER

VAD/469·1



6BW6 AMPLIFIER (Push-Pull)

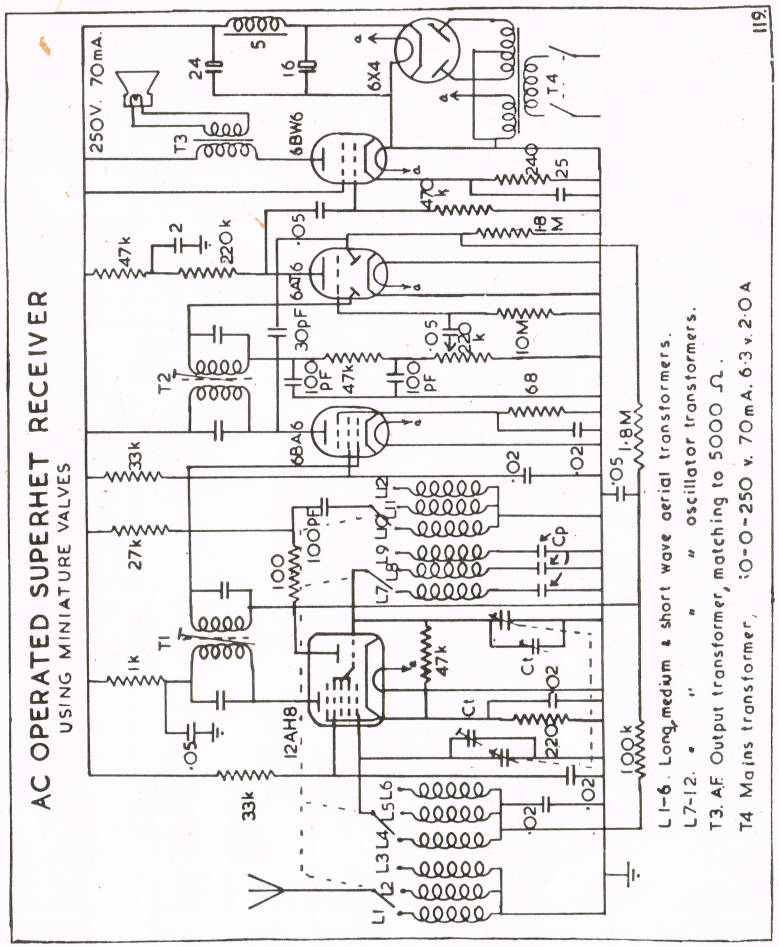
VAD/470·1

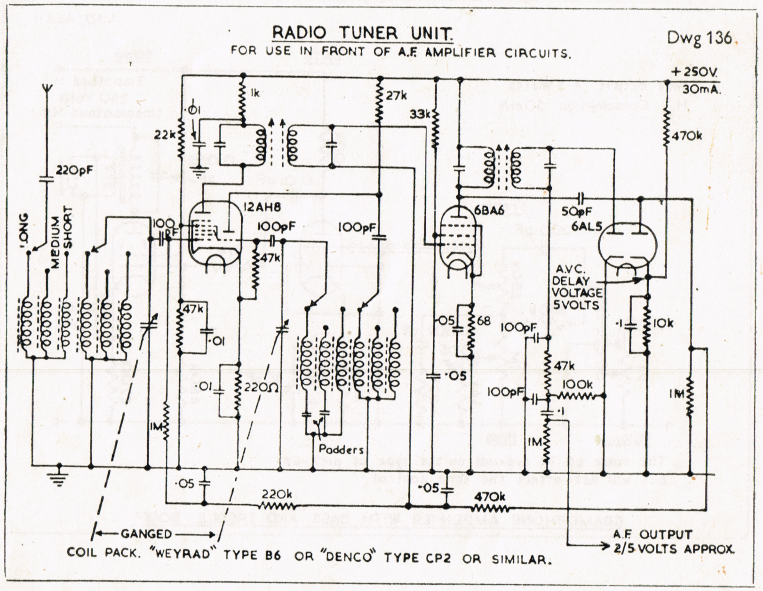


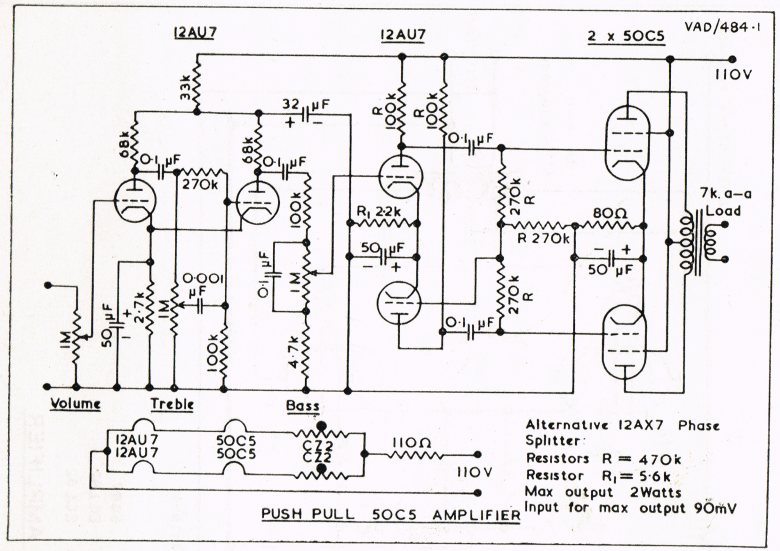
BRIMAR

AC OPERATED SUPERHET RECEIVER

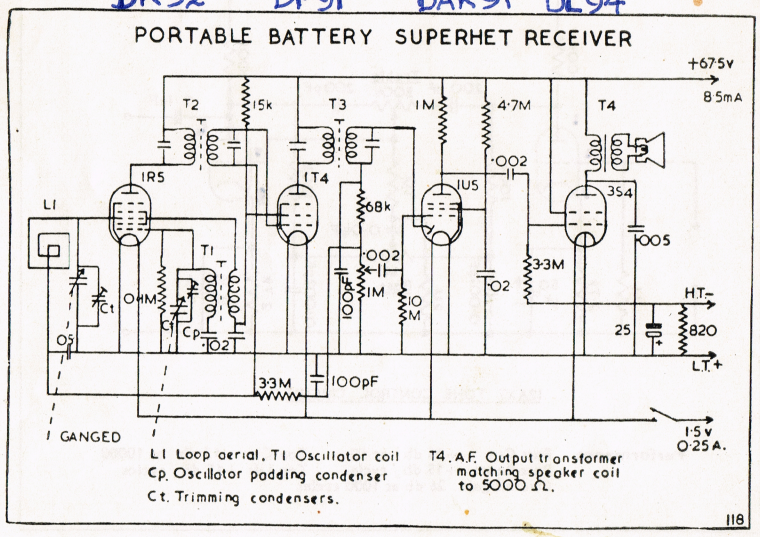
USING MINIATURE VALVES

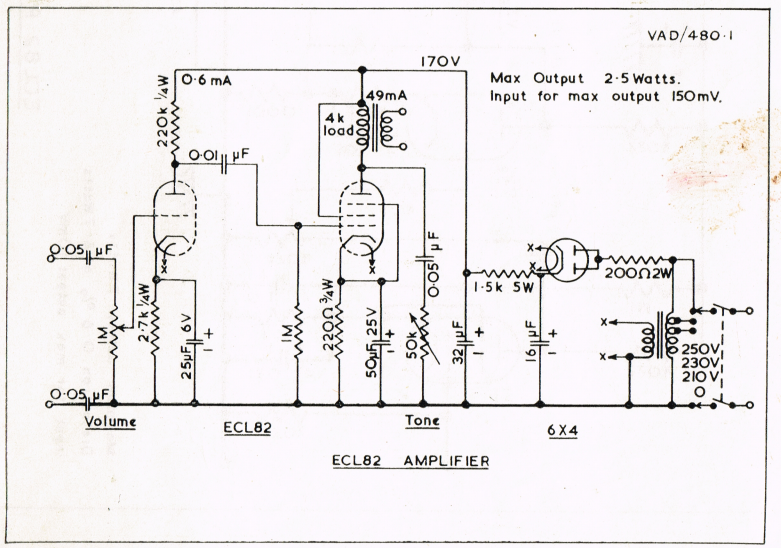




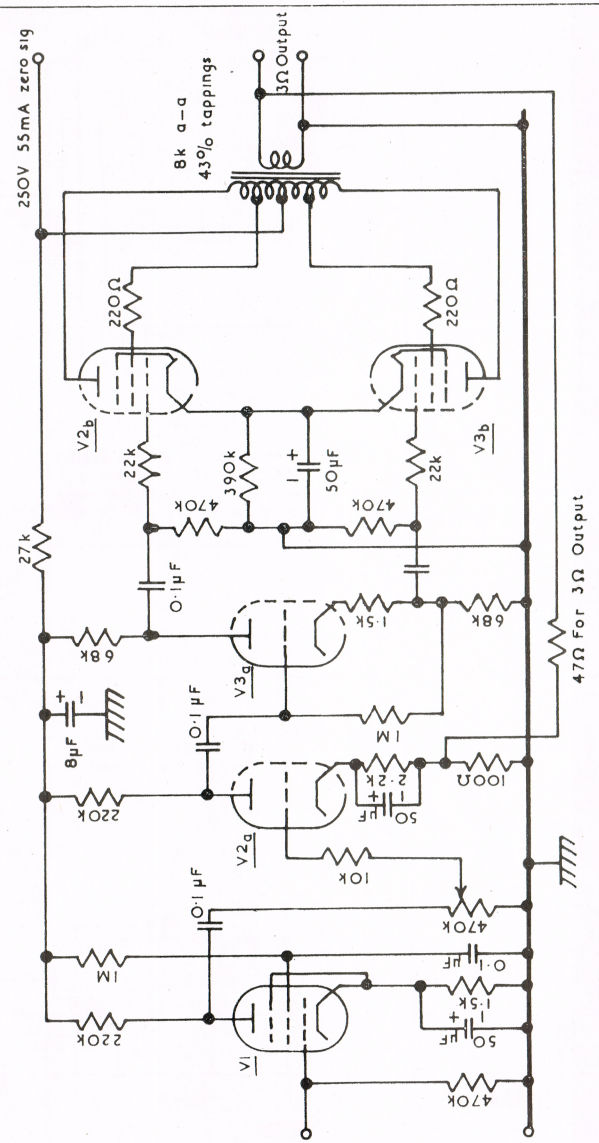


DK92 DF91 DAK91 DL94





VAD/540·1

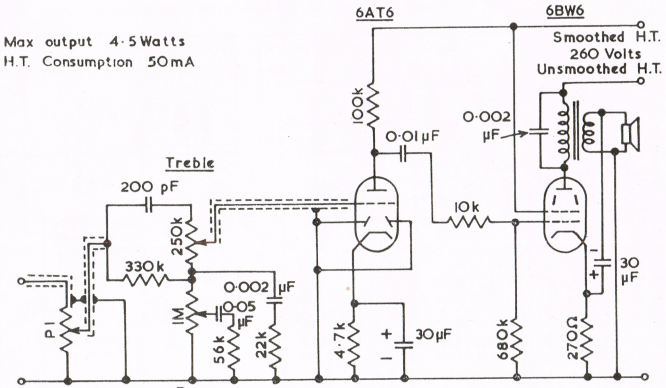


V1 6BR7
V2 ECL82
V3 ECL82

Maximum output 7 Watts
Distortion 0·6% at 6·7 Watts
Input for max output 10mV

ECL82 PUSH-PULL AMPLIFIER

VAD/453·1

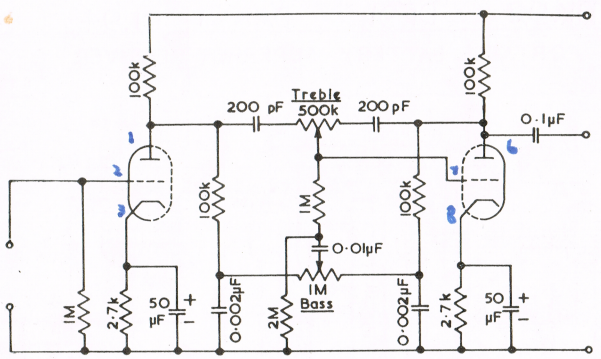


Max output 4·5 Watts
H.T. Consumption 50mA

The value of P1 depends on the type of pick-up but will not affect the tone control

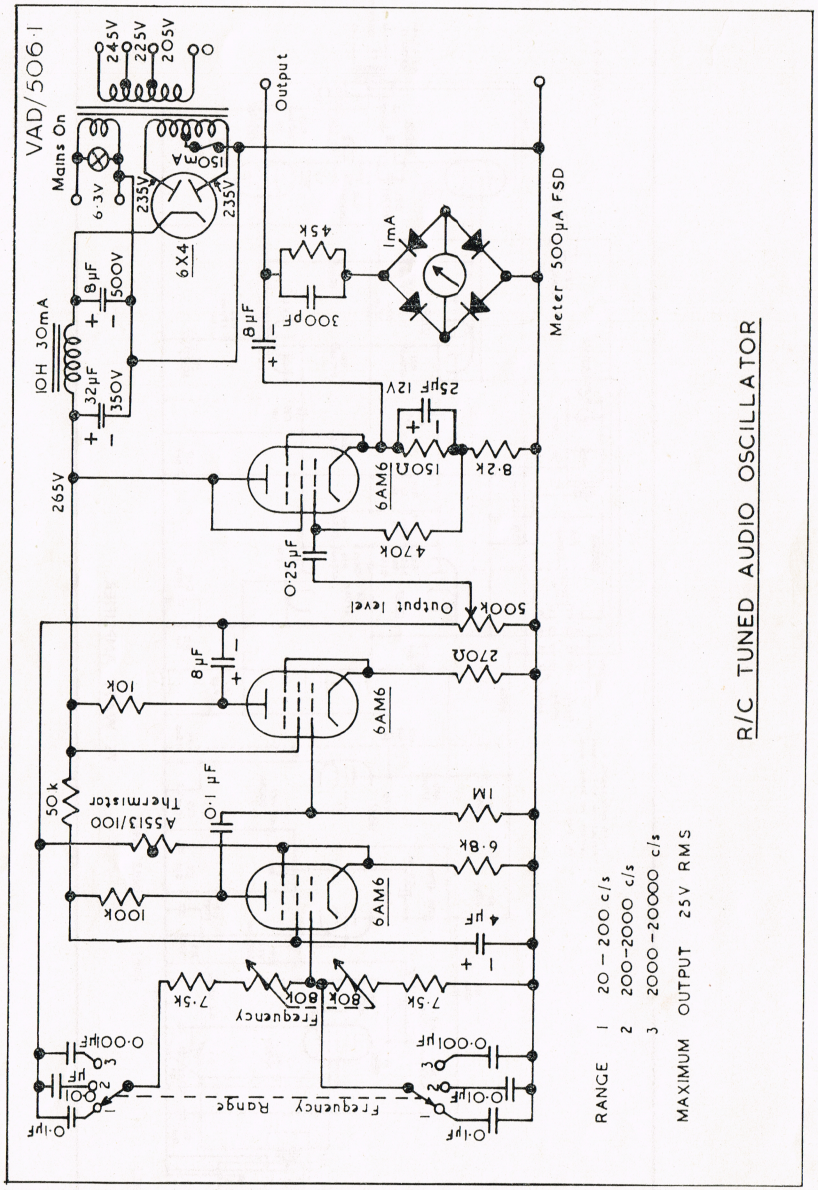
GRAMOPHONE AMPLIFIER WITH BASS AND TREBLE BOOST

VAD/488·1

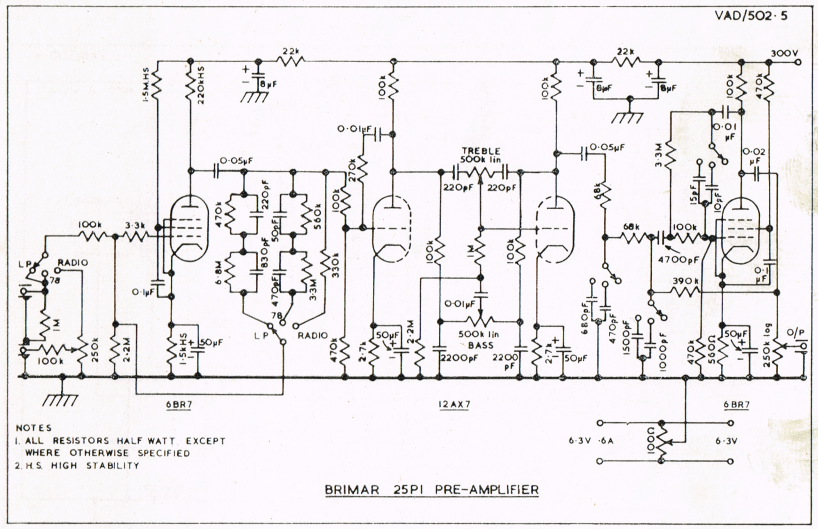


12AX7 TONE CONTROL CIRCUIT

Performance Bass Cut −15 db at 50 cycles; Top Cut −15 db at 10000 cycles
Bass Boost +15 db cycles; Top Lift +15 db cycles
Overall gain 26 db at 1000 cycles.



BRIMAR



BRIMAR 25PI PRE-AMPLIFIER

PRE-AMPLIFIER SPECIFICATION

Output 500 mV maximum into 0.5 MΩ.

Sensitivity Measured at 1,000 c/s, " BASS " and " TREBLE " controls flat, " GAIN " control at maximum.
For an output of 500 mV: Pickup LP & 78: 20 mV.
Radio 100 mV maximum sensitivity.

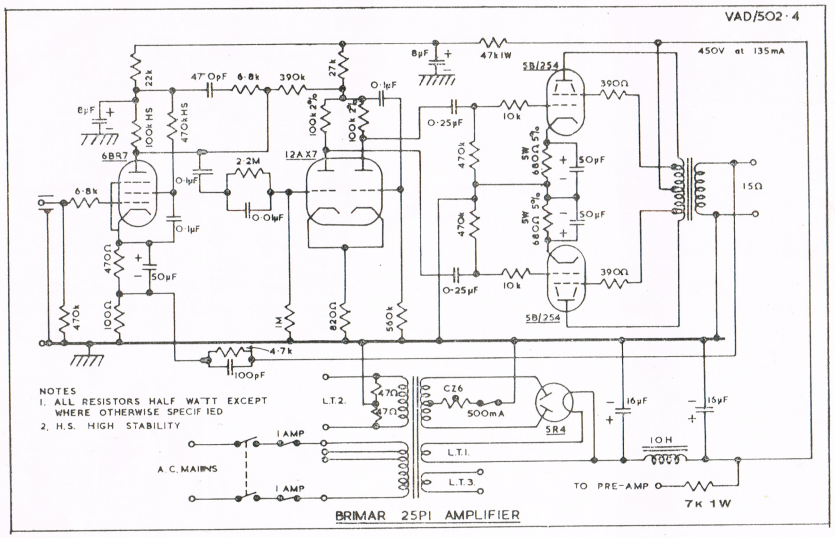
Equalising
Radio Flat response.
Pickup Compromise curves for most microgroove and 78 r.p.m. recording characteristics.

Tone Controls Continuously variable, referred to 1,000 c/s.
Treble —18 db to +18 db at 10 kc/s.
Bass —13 db to +15 db at 50 c/s.

Filters Low pass filters switchable, high pass filters permanently connected.
High Pass (" Rumble ") Cut off 35 c/s slope better than 12 db/octave.
Low Pass (" Top Cut ") Cut off 5 kc/s and 7.5 kc/s slope tending to 18 db/octave.

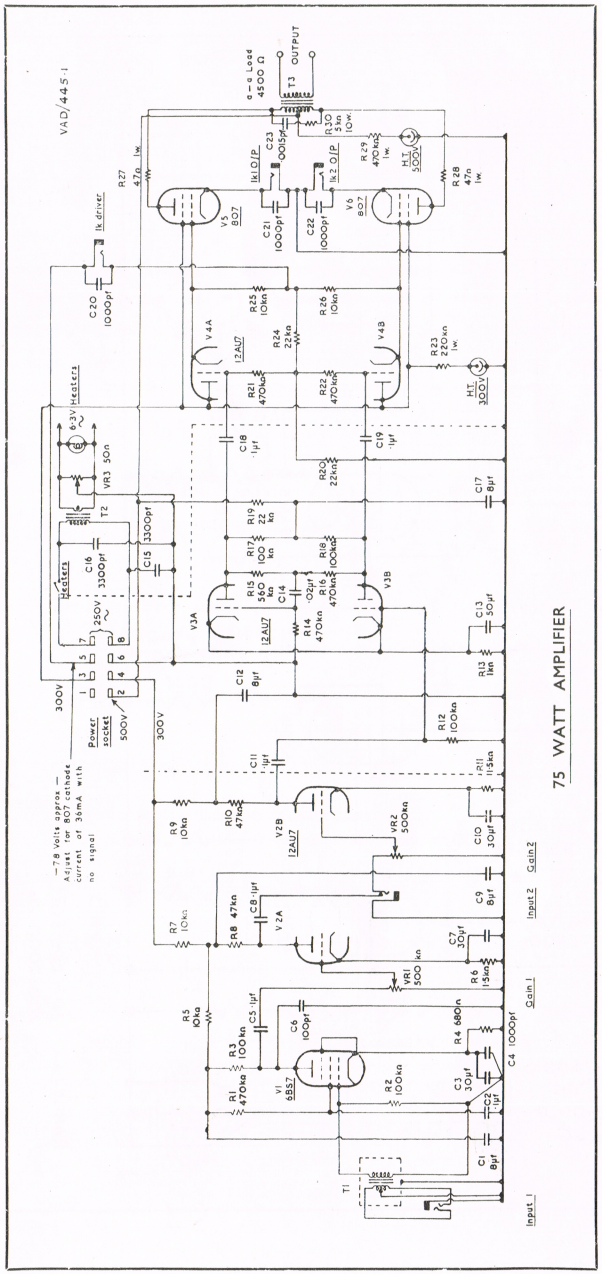
Distortion Measured at 1,000 c/s, BASS and TREBLE controls flat, GAIN control at maximum:—
For an output of 1,500 mV (*i.e.* 3 times specified maximum).
Total harmonic distortion less than 0.05 per cent. on all inputs.

Noise and Hum Measured with BASS and TREBLE controls flat, GAIN control at maximum:—
On all inputs either shorted or with 100 k load better than 58 db down at 400 mV output level.



MAIN AMPLIFIER SPECIFICATION

Power Output	25 watts into load at 1,000 c/s.
Power Response	± 0.2 db from 25 c/s to 20 kc/s.
Feedback	Main loop 35 db.
Harmonic Distortion	Total 0.1 per cent. at 25 watts.
Hum and Noise	—85 db relative to 20 watt level.
Rise Time	6 μ seconds.
Phase Shift	Less than 20° at 25 kc/s.
Output Impedance	0.4 Ω at 50 c/s and 10 kc/s.
Components	Output Transformer — S.T.C. type F.T.1. Mains Transformer — S.T.C. type F.T.2. Choke — S.T.C. type F.T.3. Valves — S.T.C. type 5B/254M. Brimar types 6BR7, 12AX7 and 5R4GY rectifier.



BRIMAR